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USNWC ltr, 30 Aug 1974

NWC TP 4464
Part 2

ENVIRONMENTAL CRITERIA DETERMINATION FOR AIR-LAUNCHED TACTICAL PROPULSION SYSTEMS

Part 2. TECHNICAL SUPPORT FOR STOCKPILE-TO-TARGET SEQUENCE

By

Howard C. Schafer
Propulsion Development Department

ABSTRACT. This report (Part 2) provides the technical support for the stockpile-to-target sequence (Part 1). Table 2 of Part 1 (the stockpile-to-target sequence) is included for convenience of the reader as a cross-reference to the chapters of this report. Each criterion presented in Part 1 is explained in an appropriate chapter. When the criterion is based on conjecture or pure guess, or where work is needed to define the environment, this is noted.

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M. R. Etheridge, Capt., USN .... Commander
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FOREWORD

This report consists of three parts:

Part 1. Stockpile-to-Target Sequence, which contains the environmental limitations in chart form for easy reference.

Part 2. Technical Support for Stockpile-to-Target Sequence, which discusses each criterion presented in Part 1 and gives the reasoning, technical limitations and work required in each area.

Part 3. Description of the Environment, which defines the environments treated in Part 1 and details an environmental frame of reference for the test engineer, designer, and project manager.

Part 1 is the part of the report which will be most widely used, Parts 2 and 3 are available as needed to support Part 1.

This work was supported by Task Assignment Number A33-536-711/216-1/F009-06-02, Problem Assignment Number 6.

This report has been reviewed for technical accuracy by Warren W. Oshel

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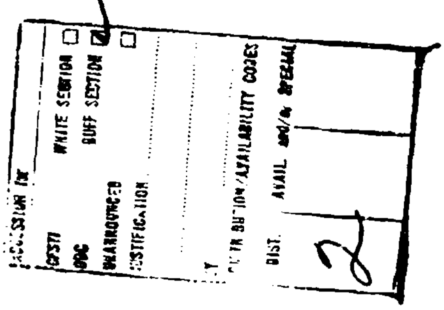

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INTRODUCTION

A stockpile-to-target sequence, when fully explained and technically supported, becomes a voluminous document. In order to reduce the volume of the more readily used portion of this composite document, the technical support sections have been organized in separate sections. Part 2 contains the detailed technical support for the criteria as setforth in Part 1, Table 2.

In general, it will be necessary to consult Part 2 and 3 only if a detailed understanding of the treated subject matter is desired. The project manager or design engineer who require an overall introduction into the current state-of-the-art of environmental criteria determination, as it pertains to air-launched tactical propulsion systems, need only review Part 1.

Caution must be taken in using the information contained in Part 2 for systems other than air-launched tactical propulsion systems. It is respectfully pointed out that a portion of the present environmental specification dilemma is directly traceable to misapplication of information obtained for a nonanalogous system. (Ref. 1.)

The chapters of Part 2 correspond to the column headings of Table 2, Part 1. For example, the fourth column of Part 1, Table 2 is entitled "Air Transportation"; as is Chapter 4 of Part 2. For each block in Table 2 of Part 1 there is a paragraph of explanation contained in the appropriate chapter of Part 2. Table 2 of Part 1 is reproduced herein only for the convenience of the reader.

TABLE 1. (TABLE 2 of Part 1). Preliminary Assumed Envir

	Transportation				Storage			
	Truck	Rail	Ship	Air	Igloo	Covered	Dump	
Temp/time (High)	120°F for 3 hr	120°F for 2 hr	90°F for 16 hr	110°F for 4 hr	100°F for 4 hr	120°F for 4 hr	140°F for 2 hr	10
Temp/time (Low)	-10°F for 36 hr	-10°F for 36 hr	40°F for 24 hr	-30°F for 4 hr	0°F for 72 hr	-10°F for 72 hr	-20°F for 72 hr	30
Relative Humidity	100% @ -10°F 95% @ 95°F 45% @ 120°F	100% @ -10°F 95% @ 95°F 45% @ 120°F	95% @ 40°F to 95% @ 90°F	100% @ -30°F to 50% @ 110°F	100% @ 0°F 95% @ 95°F 50% @ 100°F	100% @ -10°F 95% @ 95°F 45% @ 120°F	100% @ -20°F 95% @ 95°F 28% @ 140°F	10 2
Rain	2 in/hr for 1 hr	None	DNA	DNA	DNA	Negligible	2 in/hr for 2 hr	2
Ice and Hail	1 in/hr 2" buildup	None	DNA	DNA	DNA	Negligible	1 in/hr for 1 hr	
Snow	10 in/hr for 1 hr	None	DNA	DNA	DNA	Negligible	10 in/hr for 2 hr	
Corrosive Atmosphere	Negligible	Negligible	Negligible	Negligible	1/4 in. of H.R.S. per year	1/4 in. of H.R.S. per year	1/4 in. of H.R.S. per year	
Sand and Dust	45 knot wind .001 to .062 in dia partical size	Negligible	DNA	DNA	Negligible	45 MPH wind .001 to .125 in dia partical size	45 MPH wind .001 to .125 in dia partical size	
Shock	3.5 g for 25-50 m/sec	25 g for 11-18 m/sec	MIL-STD-901C values	Negligible	DNA	DNA	DNA	15, ste
Drop No damage	1 ft to dirt	1 ft to rock	5 ft to bottom of hold	1 ft to concrete	1 ft to concrete	1 ft to concrete	2 ft to dirt	2 f
Vibration	± 1 g @ 1-60 cps	± 2 g @ 10-60 cps ± 5 g @ 60-500 cps	± 0.4 g @ 5-55 cps	± 3 g @ 20-500 cps	DNA	DNA	DNA	N
R.F. Radiation Hazard	Less than 1 V/M	Less than 1 V/M	Less than 1 V/M	1 to 2 V/M	Less than 1 V/M	Less than 1 V/M	Less than 1 V/M	Le 1 V

← Unit is palletized and in container →

← Unit must survive

A

:nvironmental Criteria for Air-Launched Tactical Propulsion Systems.

	At-Sea Transfer	Airfield		Aircraft carrier		Aboard aircraft		Launch to Target
		Storage	Handling	Stowage	Handling	Jet	Propeller	
	100°F for 8 hr	140°F for 2 hr	140°F for 2 hr	90°F for 16 hr	110°F for 2 hr	240°F for 20 min to 120°F for 2 hr	110°F for 2 hr	up to 400°F for 30 sec
	30°F for 24 hr	-20°F for 72 hr	-20°F for 72 hr	40°F for 72 hr	40°F for 72 hr	-25°F for 2 hr	-30°F for 2 hr	-25°F for 30 sec
	100% @ 30°F to 20% @ 100°F	100% @ -20°F 95% @ 95°F 28% @ 140°F	100% @ -20°F 95% @ 95°F 28% @ 140°F	100% @ 40°F to 95% @ 90°F	100% @ 40°F to 50% @ 110°F	100% @ 40°F to 95% @ 90°F	100% @ 40°F to 95% @ 90°F	DNA
.	2 in/hr for 2 hr	2 in/hr for 2 hr	2 in/hr for 2 hr	DNA	2 in/hr for 2 hr	0.5 in/hr	0.5 in/hr	0.5 in/hr
:	None	1 in/hr for 1 hr	1 in/hr for 1 hr	DNA	None	None	0.5 in/hr	None
ar	None	10 in/hr for 2 hr	10 in/hr for 2 hr	DNA	None	3 in/hr	3 in/hr	3 in/hr
	Negligible	1/4 in. of H.R.S. per year	Negligible	1/8 in. of H.R.S. per year	Negligible	Negligible	1/8 in. of H.R.S. per year	Negligible
:	N.A.	45 MPH wind .001 to .125 in dia partical size	45 MPH wind .001 to .125 in dia partical size	DNA	DNA	.001 to .125 in dia partical size 100 knot Rel. Vel.	.001 to .125 in dia partical size 100 knot Rel. Vel.	DNA
	15 ft per sec to steel	DNA	15 g for 11-18 m/sec	MIL-STD-901C values	15 g for 11-18 m/sec	35 g for 5-15 m/sec	35 g for 5-15 m/sec	Detent 20 g for 30 m/sec Ejection 30 g for 5 m/sec
	2 ft to steel	2 ft to dirt	2 ft to concrete	2 ft to steel	2 ft to steel	DNA	DNA	DNA
	Negligible	DNA	None	±0.4 g @ 5-55 cps	None	.0125 g^2/cps 2-2,000 cps	±5 g @ 2-500 cps	Dependent on system
A	Less than 1 V/M	100 V/M	100 V/M	None	up to 300 V/M	up to 300 V/M	up to 300 V/M	10 V/M

survive but function not required → Satisfactory Function Required

b

Chapter 1

TRUCK TRANSPORTATION

Shipment or transfer by truck is by far the most common, and probably the most severe method of transportation. The universality of truck transportation includes all types of land surfaces from long-haul super highways through off-road forward area dump storage support.

The following assumptions are used to define the area of environmental discussion of truck transportation. (See Fig. 1 and 2.)

1. The truck can be a small pickup or a large closed van.
2. It must be driven by a man aware of his explosive cargo.
3. A truck is an all-weather, all-terrain vehicle.

FIG. 1. Military 2-1/2 ton 6x6 Van Truck.

FIG. 2. Military 2-1/2 ton 6x6 Cargo Truck.

TEMPERATURE

There is a wide range of temperature extremes to be encountered in truck transportation. The extreme temperature conditions will probably fall within the temperature envelope exhibited by van trucks when stationary. Any extremes reached in stationary open trucks would tend to be similar to dump storage and, therefore, will not be treated here.

Maximum and Duration

The maximum thermal condition would be exhibited in the cargo area of a van truck waiting to be unloaded in a desert. The thermal buildup is most extreme if the truck is stationary and there is no convection cooling.

The preliminary work used to establish the parameters was done at the Naval Weapons Center (NWC), China Lake, California. A van truck, (Fig. 1), 2-1/2 ton GMC 6x6, was filled to weight capacity and positioned for exposure. Continuous time-temperature records have been obtained for the 1965, 1966, and 1967 summer seasons. The maximum temperature reached

and recorded on any piece of ordnance therein, was 109°F. Because of incompleteness of data reduction at the time of publication, the value of 120°F is projected. Work by the U. S. Army, Natick Laboratories, tends to support the position that desert temperature measurements, recorded at NWC, are as severe as would probably be encountered worldwide.

The maximum time of exposure is recorded at 2 to 3 hours. Therefore, the maximum condition projected is 120°F for 3 hours.

Minimum and Duration

Low temperature extremes will be experienced at the storage facilities in the Continental United States and at our Alaskan stations. In the Continental United States the ambient air temperature has rarely fallen below -40°F at any place remotely connected with the NAD (Naval Ammunition Depot) system or connecting highways. Any usual set of meteorological parameters associated with air temperatures below -20°F is conducive to large snowfalls. The usual mechanism is for arctic air to come down from Siberia through Alaska and Canada into the Central United States. The cold air mass hits the warmer moist air indigenous to the area. The capacity of the warm air to hold moisture is greatly reduced when the temperature drops below freezing. The moisture falls as snow. The snowfall would then impede the movement of trucks. It is uncommon, though not unknown during long cold spells, to have -20°F clear road weather. Since the possibility of damage due to vibration and shock increases as the temperature is lowered, this parameter must be established conservatively. Temperature measurements of ordnance skin temperature while the ordnance was loaded in a 2-1/2 ton GMC 6x6 van truck were taken by NWC. The measurement spot was the U. S. Marine Corp Mountain Warfare Training Center, Bridgeport, California. The Center is physically located in the rugged Sierra Nevada mountain range on the northern boundary of Yosemite National Park. While subzero air temperatures are common, the lowest truck-borne ordnance skin temperature was -7°F for winters 1965-6 and 1966-7. The time duration for a low temperature siege is usually 24 hours or longer. Therefore, the projection is -10°F for 36 hours.

RELATIVE HUMIDITY

The moisture content of the air varies greatly within the Continental United States, and the world. It must be assumed that some truck loads of ordnance will encounter the extreme conditions.

The high desert air temperatures (Ref. 2) are normally accompanied by a low relative humidity. Other parts of the United States such as the Atlantic Seaboard, the Southeast, and the Midwest, experience moderately high seasonal temperatures with high relative humidity. The criterion

of 95°F, 95% relative humidity is experienced in these areas, though not too often. This condition is equal to an absolute humidity of 0.035 pounds of water contained in every pound of dry air. This criterion is also valid for the tropical zone. (Ref. 3.)

Any time the ambient air temperature approaches the 35°F mark or lower, the difference between 100% and 1% relative humidity is a very small amount of water. Therefore, the following criterion is projected around the maximum absolute humidity of 0.035 pounds water per pound dry air, 100% RH at -10°F, 100% at 70°F, 95% at 95°F, and 45% at 120°F.

PRECIPITATION

Loading and unloading of ordnance may be conducted during adverse conditions. The effect of bad weather is considered in the various chapters on storage.

Rain

There are very few areas traversible by trucks where rain is unknown. Rainfall in deluge proportions must be accepted as a probability. Rain of 2-inches per hour and direct impingement for 1 hour has been arbitrarily established as the guiding criterion. Rainfall greater in magnitude would probably result in impassable road conditions and field operations would be improbable. A more severe criterion would not lead to more reliable equipment and would raise the cost by unnecessary over-testing.

Ice and Hail

Hailstorms are of very short duration and affect comparatively small land areas. An ice storm of greater magnitude than herein projected would result in untenable road and field conditions. Therefore, it is projected that the ordnance may be exposed to 1-inch per hour direct impingement of hail and a possible 2-inch build-up of ice while in transit.

Snow

A snowfall of 10-inches per hour is considered to be as dense as atmospherically probable. A snow volume can be greater under unique conditions; however, all transportation would come to a standstill. It is projected that the ordnance may experience snowfall of up to 10-inches per hour for 1 hour.

CORROSIVE ATMOSPHERE

Corrosion is a time-dependent action. Since truck transportation is a relatively short time endeavor, corrosion is considered to be negligible.

SAND AND DUST

Transportation by open truck over an unsurfaced road in desert areas is the worst exposure to sand and dust that can be experienced. At this time, there is no standard, Government or otherwise, that accurately sets forth a criterion for such conditions. Abrasive effects of dust and sand vary in proportion to wind velocity. Experience gained at NWC has projected the criterion to be 3 hours of wind, varying from 30 to 45 knots, driving particles of from one micron to 1/16-inch in diameter. Direct impingement on any exposed surface will occur at an angle usually parallel to the earth's surface.

The composition of abrasive compounds in a worldwide conglomerate sample, according to an analysis done at NWC of samples collected in Thailand, Republic of the Philippines, South Viet Nam, Alaska, Canada, and the United States, would have to contain Al_2O_3 (alundum), Fe_2O_3 (jeweler's rouge), and SiO_2 (silica). At present, the S_iO_2 is the only one of these generally recognized by Military Standards.

SHOCK

It is projected that shock exposure due to loading equipment activity would be the equivalent of 3.5 g for 25 to 50 milliseconds (Ref. 4).

This is based primarily on unchecked criteria; however, the data correlates generally with other published shock criteria for truck transportation. This information needs updating.

DROP, NO DAMAGE

Normal handling activity poses no serious shock problems. Other than a handling equipment failure, the only possibility of damage in transfer of the ordnance on or off the vehicle would be due to the negligence of the loading crew; however, this negligence does exist.

The following projection is based on the assumption that the ordnance will be palletized and of sufficient weight to require handling by a forklift. Even an inexperienced crew under pressure will not drop a 1,000 pound load more than 1 foot. A drop of 3- to 5-inches is the normal situation.

It is projected that a drop in excess of 1 foot, while in the container, will not be experienced.

VIBRATION

The dynamic environment to which the ordnance will be subjected is generally described in Ref. 4. These criteria, however, lack detail as to the type of vehicle, speed, and type of terrain to which each shock or vibration level pertains. There are indications of massive amounts of shock and vibration data (Ref. 5); however, these data have not been correlated so that the dynamics of transportation can be fully assessed. It is projected from information in Ref. 4 that the ordnance will experience sinusoidal vibration at the level of 1 g and at frequencies of 1 to 60 cps.

Other data from Redstone Arsenal indicate that this exposure applies to surfaced roads and is not applicable for nonsurfaced field transport as may be encountered in forward storage dumps. This parameter is in need of updating.

RADIO FREQUENCY (RF) RADIATION HAZARD

Radio frequency energy is projected to be less than 1 volt per meter. A full discussion of radio frequency radiation environmental hazards will be found in Part 3. The 1 volt per meter exposure level, referred to in Part 3, is considered negligible.

Chapter 2

RAIL TRANSPORTATION

The rail transportation environment is similar to that of truck transportation, although less severe in most respects. Ordnance items are shipped in closed boxcars. Since there are only three major transcontinental rail routes in the Continental United States (Ref. 6), and the majority of the rail transport of these items will be in the Continental United States, the probable rail transportation environment is relatively fixed. The weather conditions encountered during transit, however, cannot be circumvented to any appreciable degree because of the fixed location of the railroad rights-of-way. A typical USNX boxcar, as used in the transportation of ordnance, is shown in Fig. 3.

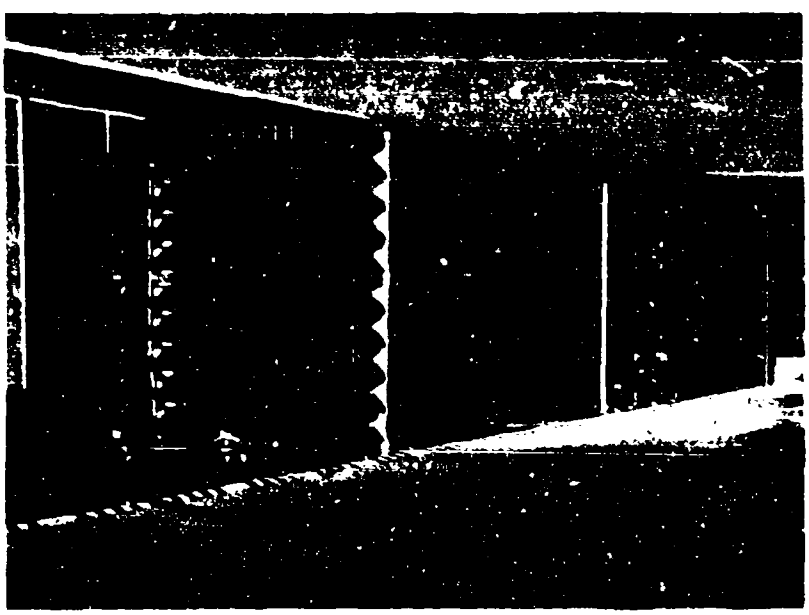

FIG. 3. Typical Naval Ammunition Boxcar.

TEMPERATURE

Maximum and Duration

The boxcar in-transit temperature environment is in most cases a mild one. It is possible, however, to have a boxcar load of ordnance stranded in a desert region in the summer. The resulting exposure would be considerably above normal (70±15°F). The boxcar, when subjected to the high solar insolation found in a pure desert climate, acts as a solar shield for the enclosed ordnance, but it also acts as a soaking oven during an extended period of 1 day or more. The Army (Ref. 7) and the Department of Agriculture have conducted research to establish the maximum expected temperatures in foodstuff. The Naval Weapons Center, in conjunction with NAD, Hawthorne, Nevada, conducted measurements to determine temperature environments of ordnance items stored in boxcars during the summer of 1965. The highest recorded temperature of ordnance or foodstuffs in any available study was 119°F.

Therefore, the maximum ordnance temperature and duration is projected as 120°F for 2 hours. This will not be experienced throughout the boxcar, but only on the side of the load next to the "hot side" of the boxcar.

Minimum and Duration

The cold criterion is based on the fact that, even during an influx of arctic air, it is uncommon when the temperate zone or even the marine-influenced subarctic is exposed to air temperatures below -10°F (Ref. 6); however, lower temperatures have been experienced on occasion. These low temperature conditions are usually accompanied by snow. (As the ambient air temperature becomes lower, much less free moisture can be held. This moisture upon condensation usually takes the form of snow.) The remote possibility exists that the in-transit boxcar could be stranded in such a situation. In a snowbound condition, the ordnance would be considered as governed by covered storage limitations and the ordnance could be soaked to a low temperature. When moved out of the snowdrift, the possibility of vibration damage to the ordnance would increase as the temperature lowers. Therefore, a conservative -10°F for 36 hours is recognized, although its occurrence is considered remote.

RELATIVE HUMIDITY

The temperature and humidity conditions in a closed boxcar are equivalent to those induced in a closed test chamber. This situation is one where the total volume of water content versus total air volume does not vary appreciably and the RH becomes completely a function of temperature fluctuation. Thus, if the temperature drops past the dew point, condensation will form on the exposed ordnance surfaces. As the temperature

rises, the captive air can hold a greater amount of moisture, causing the RH to drop. (The absolute humidity is a constant value.)

Relative humidity is projected to be:

100% at -10°F	95% at +95°F
100% at +70°F	45% at +120°F

PRECIPITATION

Since rail transportation is in closed boxcars, precipitation exposure is limited to loading and unloading activities. Such periods will be of short duration and establish no area of critical concern.

CORROSIVE ATMOSPHERE

Corrosion is a time-dependent tion and rail transportation is considered of short time duration. Theref re, the corrosion potential is negligible and would become significant only when added to storage conditions after movement.

SAND AND DUST

Boxcars used to transport ordnance are closed during transit and would be relatively free from outside distrubance. The air velocity within the boxcar will be so low that sand or dust damage would be negligible. Any impingement would be on the container of the ordnance.

SHOCK

The shock criterion associated with "humping" during train makeup is relatively severe. Starting and braking of freight trains is far from smooth and shock application varies with the length of the train and the distance of the specific boxcar from the locomotive. Therefore, the projection is for a shock level of 25 g over 11 to 18 milliseconds duration (Ref. 4).

DROP, NO DAMAGE

Normal handling activity poses no serious shock problems. Other than a handling equipment failure, the only possibility of damage in transfer of the ordnance on or off the boxcar would be due to the negligence of the loading crew.

This is based on the assumption that the ordnance will be pal'^tised and of sufficient weight to require handling by a forklift. Eve. .. inexperienced crew under pressure will not drop a 1,000 pound load more than 1 foot. A drop of 3- to 5-inches is the normal situation.

It is projected that a drop in excess of 1 foot will not be experienced.

VIBRATION

The dynamic environment of the railroad boxcar was projected using data from Ref. 4. The vibration criterion is projected to be ±2 *g* at 10 to 60 cps and ±5 *g* at 60 to 500 cps. A boxcar carrying its full weight capacity of ordnance would probably experience the low frequency spectrum, but the high frequency spectrum is not likely to be experienced. This information is not completely verified, and needs more investigation.

RADIO FREQUENCY (RF) RADIATION HAZARD

Based on data discussed in Part 3, the radio frequency radiation exposure will be less than 1 volt per meter while ordnance is loaded on railroad equipment.

Chapter 3

SHIP TRANSPORTATION
(AMMUNITION OR MERCHANT SHIP)

Generally speaking, the environmental criteria associated with sea transport are less severe than most other areas in the stockpile-to-target sequence of air-launched propulsion systems. Overseas shipment of the ordnance will be accomplished either by Naval ammunition ships (Fig. 4) or merchant ships under charter (Fig. 5). Cargo handling crews will vary in their knowledge and ability as will the cargo vessels in their interior hold accommodations.

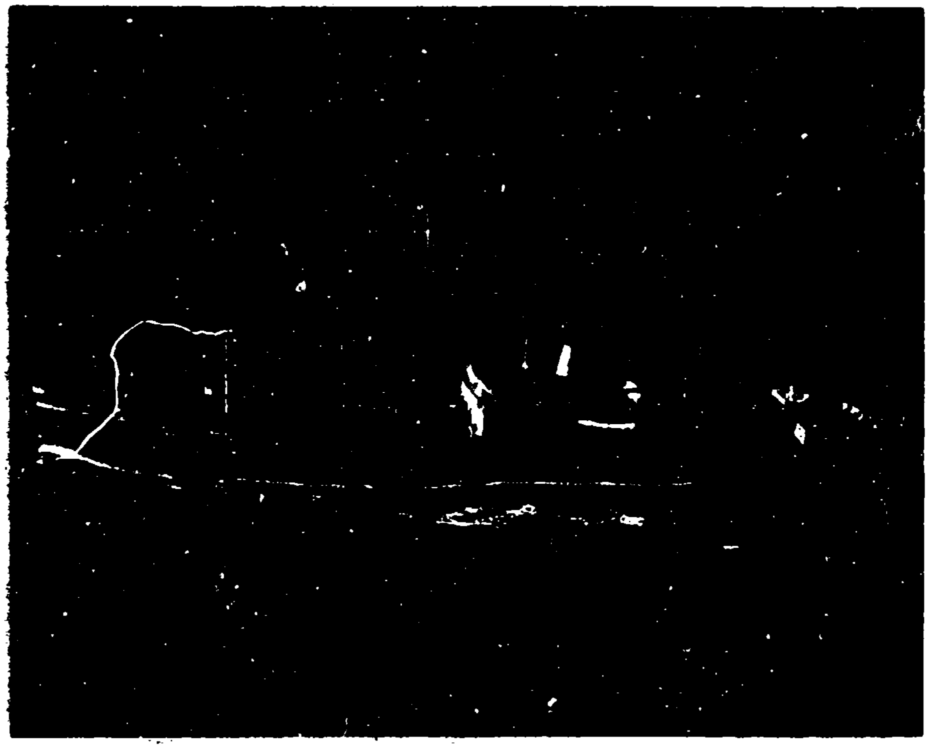

FIG. 4. Typical Naval Ammunition Ship. USS Suribachi (AE-21).

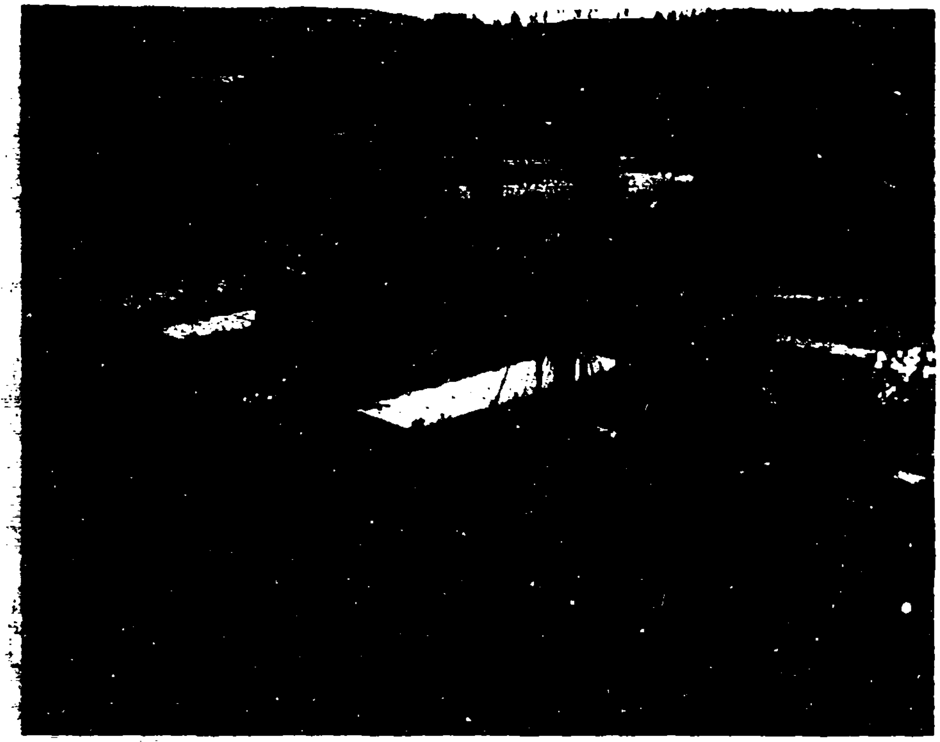

FIG. 5. Typical Victory Ship.
(Berea Victory.)

TEMPERATURE

Maximum and minimum temperatures in the hold of a ship are directly related to the temperature of the surrounding seawater. Ordnance is stored in magazines below the waterline.

Maximum and Duration

The maximum worldwide seawater temperature record is 95°F, taken in the shallow water of the Persian Gulf. The tropics, however, very seldom display seawater temperatures above 85°F (Ref. 1 and 9). The magazine temperature records forwarded to NWC from ammunition ships indicate that the high air temperature consistently recorded in the magazine is 80°F.

There is no record of the ordnance temperature in cargo ship holds and the possibility of above-waterline stowage does exist. Bases upon the available information (Ref. 1 and 9), it is projected that the maximum temperature be established at 90°F for a 16 hour period.

Minimum and Duration

Since seawater is not fluid below 27°F, and cargo ships are deployed only in liquid state oceans, it will be assumed that this is the lower limit. In general, the recorded minimum ammunition ship magazine temperature is near 50°F. Again, however, no data exist for cargo ships. Therefore, the projected minimum temperature criterion is 40°F for 24 hours.

RELATIVE HUMIDITY

The RH experienced by the ordnance in an ammunition or cargo ship will generally be high. Therefore, the projection is for up to 95% RH at temperatures ranging from 40 to 90°F.

PRECIPITATION

Ordnance is not carried above deck except for at-sea replenishment; therefore, precipitation of any kind will not directly strike the ordnance. The 24 hour pretransferral period during sea transfer is discussed in the chapter on "At-Sea-Transfer".

CORROSIVE ATMOSPHERE

Location of ordnance during storage aboard ammunition ships is very carefully planned and protected, with no exposure to corrosive atmosphere other than indigenous sea air. The exposure of the ordnance in a cargo ship will be similar, although the time duration will be minimal. Because of the short time duration, it is projected that the corrosive effects will be negligible. However, because of possible storage in ammunition ships for extended periods of time this projection should be investigated.

SAND AND DUST

Sandstorms have been reported over coastal waters in various parts of the world; however, this is chance happening and will not be recognized as a us circumstance. Sand and dust exposure is considered nonexistent.

SHOCK

It is considered at this time that shock criteria established by the Bureau of Ships (BuShips) investigation and set forth in MIL-STD-910C, are acceptable. However, the shock parameters should be made available instead of specifying a shock testing machine. Until more definitive

work is undertaken to establish the shock spectrum for munitions in sea transit, the criteria as stipulated in MIL-STD-910C are acceptable.

DROP, NO DAMAGE

The shock environment, associated with a Naval ammunition ship, is in general the least severe of the several shock phenomenon in the air-launched tactical rocket motors stockpile-to-target sequence. The crew of a commissioned ammunition ship (AE) can be expected to be the best trained and the best indoctrinated of any Naval ammunition handler. Navy safety precautions, which become the rule of a crew preoccupied with explosive handling, and self-interest govern a carefully trained ship's company. The few exceptions to the standards of an AE crew - notably newly commissioned and hastily trained ship's crews - could well extend the parameters of shock experienced to a level commensurate with combatant ships, the difference being merely the packaging (palletized versus individual round) of the ordnance.

The handling of ordnance aboard merchant vessels may differ to some degree in that qualification standards of stevedores are far from uniform when veiwed from a worldwide standpoint.

The maximum drop of the palletized ordnance is projected to be 5 feet to the bottom of the hold.

VIBRATION

The vibration environment as specified in MIL-STD-167 (Ships) is adequate. The energy levels therein are severe because MIL-STD-167 (Ships) is required for use during design of ship engines, turbines, propeller shafts, and other massive castings associated with the engine room and engineering spaces. The cargo holds should not transmit the complete high energy levels to the palletized munitions, much less magnify them. Until more definitive work is undertaken to establish the vibration spectrum of munitions in the ammunition ship cargo-hold environment, the criteria as stipulated in MIL-STD-167 (Ships) are acceptable.

RADIO FREQUENCY (RF) RADIATION HAZARD

Radio frequency radiation intensity is projected at not to exceed 1 volt per meter. This value is probably high because the ship's hull tends to act as a Faraday cage, completely shielding the ordnance item from radio frequency energy. The degaussing procedures used throughout the Fleet will cause no electromagnetic hazards because all degaussing is done with direct current.

Chapter 4

AIR TRANSPORTATION

The air transportation of ordnance, as heavy and as rapidly expendable as air-launched tactical propulsion systems, is debatable. Since the probability exists of this occurring in a limited war situation, the possibility must be explored.

The largest transport aircraft presently available, the C-133 (Fig. 6) and C-141, have a gross cargo capacity that would accommodate about 50,000 pounds of ordnance at continental distances.

FIG. 6. Air Force Cargo Aircraft, C-133.

It must be remembered that cargo aircraft can lift only an established gross load. Over short distances, the major proportion of the gross load will be cargo; however, long flights require a full capacity of fuel resulting in lighter payloads. Since the mass of a load is the paramount parameter in the response of the load to a given forcing function, this fact must be kept in mind. This area of the environment needs work done on all parameters.

TEMPERATURE

In general, the temperature matrices of cargo aircraft are analogous to those of boxcars. The cargo is shielded from solar insolation and the mass of the cargo limits extensive temperature changes in the short time of flight.

Maximum and Duration

The hypothetical maximum extreme temperature would be derived from a forced landing on a desert airfield with a following multiday wait for repairs. This is a very unlikely situation. In an emergency situation warranting air shipment of ordnance, another aircraft would be made available to continue the cargo on its way immediately. Therefore, the cargo would not be normally exposed to the unshielded extreme temperatures of an aircraft sitting on a desert airfield. The maximum ordnance temperature expected in an aircraft cargo compartment during an extended wait of about 24 hours could be 110°F. However, the mass of the shielded cargo would not allow it to thermally follow the air temperature and the aircraft fuselage would not allow the sun's rays to impinge directly on the ordnance. Therefore, 110°F for 4 hours is projected as being the maximum ordnance temperature.

The desert warfare situation in which Naval ordnance would be used would require that the cargo aircraft be unloaded immediately after landing. Assuming that the need for the ordnance was great enough to warrant air shipment, the cargo would be unloaded within 24 hours. In this circumstance, the high temperature would parallel that of dump storage under similar geographic conditions. There is no retrievable documentation available indicating that this parameter has been seriously studied.

Minimum and Duration

Outside temperatures encountered by transport aircraft become lower as higher altitudes are reached. Outside air temperatures of -40°F are common at the altitudes flown by cargo aircraft. However, cargo flight times in excess of 10 hours are not anticipated and it is doubtful that even a maximum time flight at such low temperature would result in a partial ordnance soak condition lower than -30°F, reached over a period of 6 hours. Therefore, -30°F for 4 hours is projected as being the minimum ordnance temperature. This projection appears to be most conservative, yet should be investigated.

RELATIVE HUMIDITY

Relative humidity is projected to range between 100% at -30°F and 50% at 110°F. The relative humidity effects, other than condensation,

are minimal because of the short duration of flight. The ordnance in its container should not be affected in any way.

PRECIPITATION

Loading and unloading of the ordnance could conceivably be conducted during various adverse weather conditions but the effect of foul weather need not be considered. The C-133, for example, is not an all-weather aircraft; therefore, it would not be flying into or out of foul weather. If true all-weather aircraft are produced, the precipitation exposure on loading and unloading would concern the container only.

CORROSIVE ATMOSPHERE

Corrosion is a time-dependent action and aircraft transportation is considered of short time duration. Therefore, the potential for corrosion is negligible and would become significant only when added to storage conditions after movement.

SAND AND DUST

Air transportation routes are above the level of sandstorms and since cargo aircraft are relatively sealed, there will be no sand or dust exposure.

SHOCK

Cargo aircraft structure is relatively fragile. A shock level sufficient to cause even minor damage to ordnance would result in visible structural damage to the aircraft. Therefore, it is projected that in air transportation negligible shock exposure will be experienced.

DROP, NO DAMAGE

The possibilities of dropping the ordnance during loading or unloading are about the same as would be encountered in truck and rail transport. Cargo decks on some air transports present a greater possible drop distance. However, the types of handling equipment attendant to air cargo handling are more specialized and more efficiently handled than those at the less sophisticated truck and rail loading dock facilities. The projected drop of 1 foot with no damage would be to the aluminum floor of the aircraft and would occur infrequently. A possible 1 foot drop to the concrete "hard stand" should also be considered.

VIBRATION

The dynamic environment of a turboprop aircraft is probably the most extreme of any type of air transportation. The quantitative analysis of the vibration spectrum is reported in Ref. 8. Experience, based on one 3,000 mile flight loaded with 20,000 pounds of NWC cargo, indicates that the values reported are correct, although possibly not entirely conservative. If the assumption of a full weight load of ordnance is observed, however, these values should be reduced by a given percentage because the gross volume being excited is a much larger mass than the aircraft's empty cargo deck or the fuselage skin. This derating factor is at present unknown; however, it is projected that the vibration level will be 3 *g* at 20 to 500 cps. This conjecture should be investigated.

RADIO FREQUENCY (RF) RADIATION HAZARD

The possibility of exposure of the ordnance to high levels of radio frequency energy during air transport is negligible. The levels of radio frequency found on an aircraft carrier flight deck may be ignored since cargo aircraft cannot land on an aircraft carrier. Airfields that can handle a large transport aircraft are vast enough to dissipate radio frequency energy by distance alone; therefore, exposure of from 1 to 2 volt per meter is the assumed criterion.

Chapter 5

EXPLOSIVE HAZARD MAGAZINE (IGLOO) STORAGE

The most prevalent storage facility in the Navy is the standard earth-covered, ventilated explosive hazard magazine (igloo) (Fig. 7). The dimensions and construction generalities for igloos are delineated in OP-5 (Ref. 10). The NAD and Naval Magazine (NM) facilities throughout the world are equipped with these standardized concrete and dirt storage structures. The basic thermodynamic principle used in igloo design is that a thick layer of soil is a good temperature barrier. Experiments conducted in 1954, 1955, and 1956 at NOTS (presently the Naval Weapons Center, China Lake) by C. A. Taylor indicated that the maximum annual temperature variation 12 feet below the surface of the earth was about 12°F. This is in light of the annual 9 to 110°F variation of air temperatures 5 feet above the earth's surface.

FIG. 7. Typical Explosive Hazard Magazine (Igloo).

The investigation showed that the 12 foot deep temperature reached a minimum of 64°F during May and a maximum of 76°F in October. At this depth there is no diurnal temperature variation. There is no yearly fluctuation of temperature 26 feet below ground level.

TEMPERATURE

Since the igloo is covered with at least 1 foot of dirt (specifications, Ref. 10, for new structures require at least 2 feet), the stored items are not subject to drastic diurnal temperature variations. The temperature of stored ordnance inside an igloo is moderated by the lack of variation of the enclosed igloo air temperature. As a rule of thumb, the ordnance temperature can be expected to be no more, nor less, than the average daily standard air temperature for the season in question.

Maximum and Duration

The maximum temperatures to be expected in desert explosive hazard magazines can be statistically reviewed in Ref. 12. This NWC report covers the American Desert for the greater portion of a solar cycle and indicates that a 100°F igloo air temperature can be adjudged as the extreme. The high temperatures to be expected in the Western Pacific areas is covered in Ref. 13, and the Okinawa and Japan areas in Ref. 14. After consultation of Ref. 12, 13, and 14, it is concluded that 100°F for a period of 4 hours is the extreme.

Minimum and Duration

Unpublished data available at NWC of the same caliber as Ref. 12, 13, and 14, indicate that in igloo storage facilities in the ocean-induced arctic (Anchorage, Alaska; Kodiak Island, and Adak Island) the minimum temperature reported is +18°F. The minimum temperature was measured during the winter of 1961-2 when Alaska and the arctic in general, experienced the lowest temperatures since 1937. Information from NM, Brunswick, Maine, indicates a +2°F in the winter of 1965-6. Since this unverified information seems to be factual, it must be recognized, therefore, the projection is for 0°F for 72 hours. (Ref. 11.)

RELATIVE HUMIDITY

The relative humidity associated with igloo storage temperature is dependent on the absolute humidity of the air. It is conceivable that the 85°F in the magazine could subject the item to 95% RH (Ref. 3). The desert induced 100°F temperature is commensurate with a 5 to 35% RH. There is no possible natural situation where the general MIL-STD value

of 160°F, 95% RH situation can exist in nature. It is projected that the RH will vary from 95% at 95°F to 50% at 100°F.

PRECIPITATION

The standard storage igloo is a completely enclosed structure, thereby precluding any direct precipitation contact with the stored ordnance. A flooded igloo is a common occurrence in the tropics; however, the water level seldom reaches more than a few inches. Ordnance can also be soaked from roof leakage.

CORROSIVE ATMOSPHERE

Outside the Continental United States, the igloo-stored ordnance item can be subjected to salt air exposure. In the tropical zone the bacteriological content of the air is appreciable (Ref. 15). The MIL-STD tests for atmospherically-borne contaminations are in no way representative of the environment. Work needs to be done in both the salt air and biological contaminant areas. The contamination levels at NAD, Oahu, and NM, Guam, have contributed to the reduction of the useful service life of items stored there for Fleet use. Indications have been that items having a normal 3 year storage life are largely unserviceable after a 2 year storage period in the Pacific area. Quantitative and qualitative measurements to define the problem have not been made. The condition of stored items, however, strongly indicates that the magnitude of the problem is severe. An introductory discussion of corrosive atmosphere is given in Part 3.

SAND AND DUST

Sand and dust destructive levels are directly traceable to the wind velocity. Igloos are windproof, therefore, the erosive effect of sand and dust is negligible.

SHOCK

The shock environment is simplified by the universal practice of palletizing loads and the use of forklift equipment. There is no shock spectrum other than that indicated in the next paragraph.

DROP, NO DAMAGE

A drop of 3- to 5-inches is considered as the maximum that the palletized load will experience during stacking activity within the igloo. As in the case of "Truck Transportation", the 1 foot criterion is projected.

VIBRATION

Storage is a nondynamic situation and there will be no movement of the ordnance as generally associated with vibration.

RADIO FREQUENCY (RF) RADIATION HAZARD

The igloos are spaced well apart and generally away from other service areas for safety reasons. This remoteness from transmitters alone weakens any radio frequency field strength. The physical elements of the igloo (dirt and concrete) also attenuate electrical impulses in the area. Therefore, radio frequency radiation hazard will not be more than 1 volt per meter.

Chapter 6

COVERED STORAGE

There is an intermediate storage situation between the harsh dump type storage and the relatively ideal explosive hazard igloo magazine situation. This intermediate consists of a situation where some protection is offered, although primitive (Fig. 8). Anything that will cover the ordnance item, yet allow circulation of air, will greatly modify the environment. In practice, the usual intermediate is the Quonset hut or Butler hut. The other field expedients are usually wood and canvas structures that consist almost entirely of a roof and open sides. This type of structure is discussed in Ref. 12 and 13.

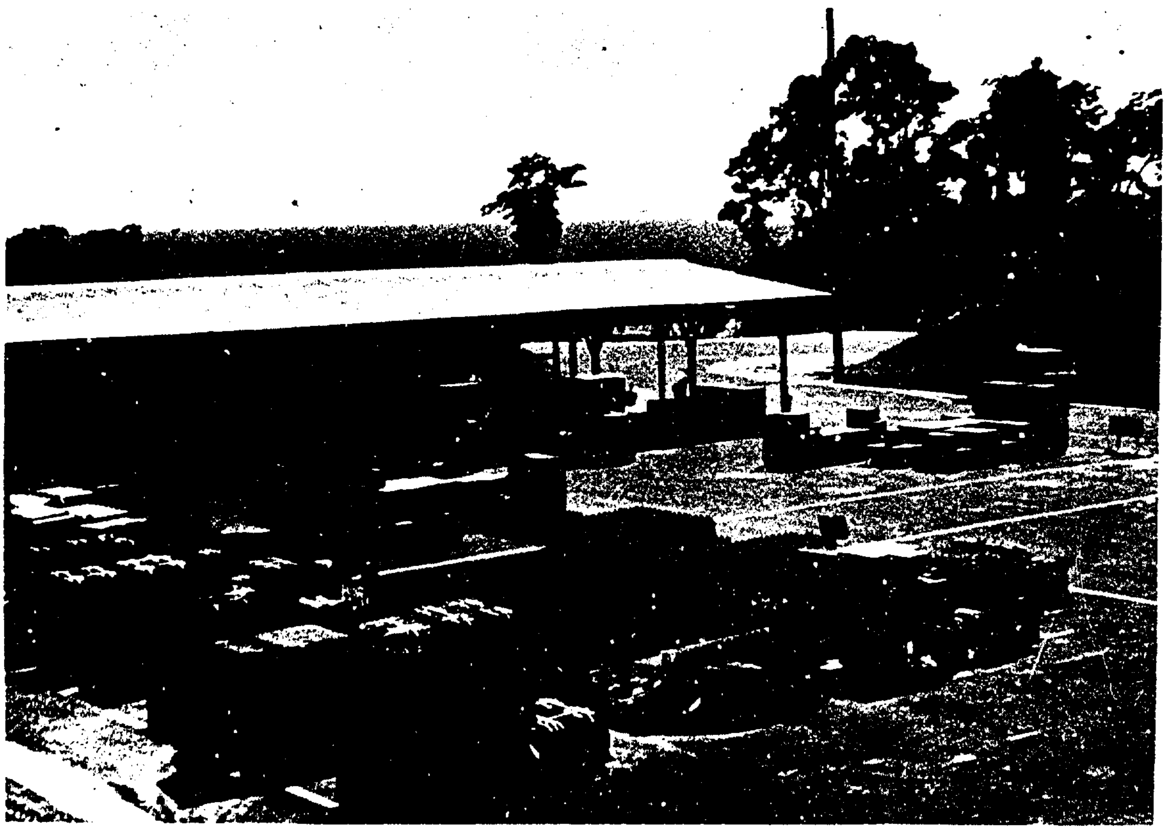

FIG. 8. Typical Primitive Covered Storage Shed.

TEMPERATURE

Maximum and Duration

The maximum air temperature reached by an ordnance item sheltered from the sun is much less than that to be expected if the units are directly exposed. The radiation shield of a relatively flimsy canvas tarpaulin will afford protection such that the ordnance will reach temperatures no higher than the free air. A fallout of work published as Ref. 12 and 13 showed that even at Yuma, Arizona, and Subic Bay, Republic of the Philippines, the free air temperature in a primitive structure did not reach temperatures over 120°F. The time of exposure to the maximum temperature is not reported in Ref. 12 or 13; however, an educated guess would be no more than 4 hours maximum. The heavy air-launched tactical propulsion system would be massive enough so that the unit would probably experience temperatures approximating the free air mean temperature. Another educated guess indicates that this would be approximately 90 to 100°F for pure desert or 80 to 85°F for tropical exposure. Since empirical measurements have not been made to substantiate this, the projection is for 120°F for 4 hours.

Minimum and Duration

The data on the cold weather excursion for covered storage are less complete than for hot weather. Work now in progress at NWC indicates that the lowest air temperature of record in covered storage at Anchorage, Alaska, or Kodiak and Adak Islands in a Butler or Quonset type building is -4°F. The time duration is assumed to be around 3 days. (These data are obtained from studying the maximum-minimum temperature cards collected to satisfy ammunition safety requirements.) Therefore, the projection is for -10°F for 72 hours. (Ref. 11.)

RELATIVE HUMIDITY

The relative humidity associated with covered storage temperatures is commensurate with the relationships associated with free air. It is conceivable that a maximum situation of 45% RH at 120°F may be experienced. This equivalent to 0.035 pounds of water per pound of dry air. At -10°F the air will be saturated so the projection would be 100% RH at -10°F.

The range between maximum and minimum temperatures with commensurate relative humidities is as follows:

100% at -10°F	95% at +95°F
100% at +70°F	45% at +120°F

It is again noted that there is no possible natural situation where the general MIL-STD value of 95% RH at 160°F can exist.

PRECIPITATION

The covered storage situation is by definition at least a partial shield against precipitation. The protection may or may not be complete. The projections being made assume that the coverage is less than complete.

Rain

All types of rainfall must be assumed and considered as probable. Therefore, the projection is for 2-inches per hour direct or indirect impingement for a duration of not more than 2 hours. The volume of rain discussed is extremely unlikely even in tropic areas. That much rain will flood any non-hillside area, or make entrance or egress most unlikely.

Ice and Hail

Ice or hailstorms may be disastrous to the temporary shelters due to ice build-up. An educated guess is that ice build-up of 1-inch per hour on exposed ordnance may occur for 1 hour. Hail may approach 1-inch per hour direct impingement on exposed ordnance for less than 1 hour.

Snow

The snowfall projection is established at a maximum probability of 10-inches per hour for 2 hours. During these conditions the snow would drift into any exposed ordnance.

CORROSIVE ATMOSPHERE

Since most Naval storage facilities are near salt water, corrosion of exposed surfaces can be expected. This corrosion can be extremely severe in semitropical storage sites. Salt corrosion under these conditions is a function of the distance from the surf. Corrosion rates at 80 feet from the surf are nine times greater than those of identical specimens located 620 feet from the surf at the same geographical location (Ref. 19). Biological corrosion is a function of location and latitude. Because the quantitative magnitude is unknown, only a qualitative value can be given. It is projected that the exposure will be severe. The expression of this severity is a pure guess, i.e., 1/4-inch of hot rolled steel dissipated per year.

SAND AND DUST

If the coverage of the storage building is complete, then this section may be disregarded. However, if the shelter consists of a roof only, then no protection is extended against sand and dirt. Along with pure dump storage, this exposure is the most extreme for sand and dust throughout the stockpile-to-target sequence. The only saving grace is that the unit will probably be inside a storage container.

Work done at NWC has preliminarily determined that there must be more information collected to define the sand and dust problem. This work indicated that a worldwide dirt sample would have to contain Al_2O_3 (corundum), Fe_2O_3 (jewelers rouge), and silica. The particle size distribution would have to include 16 micron mean particle size units to 1/8-inch diameter pea gravel. The wind velocity range should include speeds up to 45 miles per hour. As is apparent, the above is not completely defined and needs a logical sequencial investigation.

SHOCK

The shock environment is simplified by the universal practice of the palletizing of light items. Therefore, all units will be handled by a forklift. There is nc shock criterion other than that specified under "Drop, No Damage".

DROP, NO DAMAGE

A drop of 3- to 5-inches is considered the maximum that a heavy, or palletized load will experience during stacking inside the covered shelter. Since no work other than personal observation has been done on this parameter, the criterion of a 1 foot drop is projected.

VIBRATION

Storage is a nondynamic situation and there will be no movement of stored items as generally associated with vibration.

RADIO FREQUENCY (RF) RADIATION HAZARD

Storage structures are spaced well apart and generally well away from other service areas for safety reasons. The remoteness from radio and radar transmitters alone will weaken any radio frequency field strength. Therefore, radio frequency radiation hazard will be negligible, or not more than 1 volt per meter.

Chapter 7

DUMP STORAGE

Investigation of the literature associated with open dump storage (Fig. 9) temperature extremes has indicated that the exposures were conducted with either Army Quartermaster or ordnance items (Ref. 16). No temperature data other than meteorological were usually recorded. Exposure criteria are fundamentally basic; i.e., whether or not the item functions after the extremes of the winter or summer seasons are over. Therefore, there are some assumptions that must be made so that the data, although sketchy, may be correctly applied to Naval ordnance.

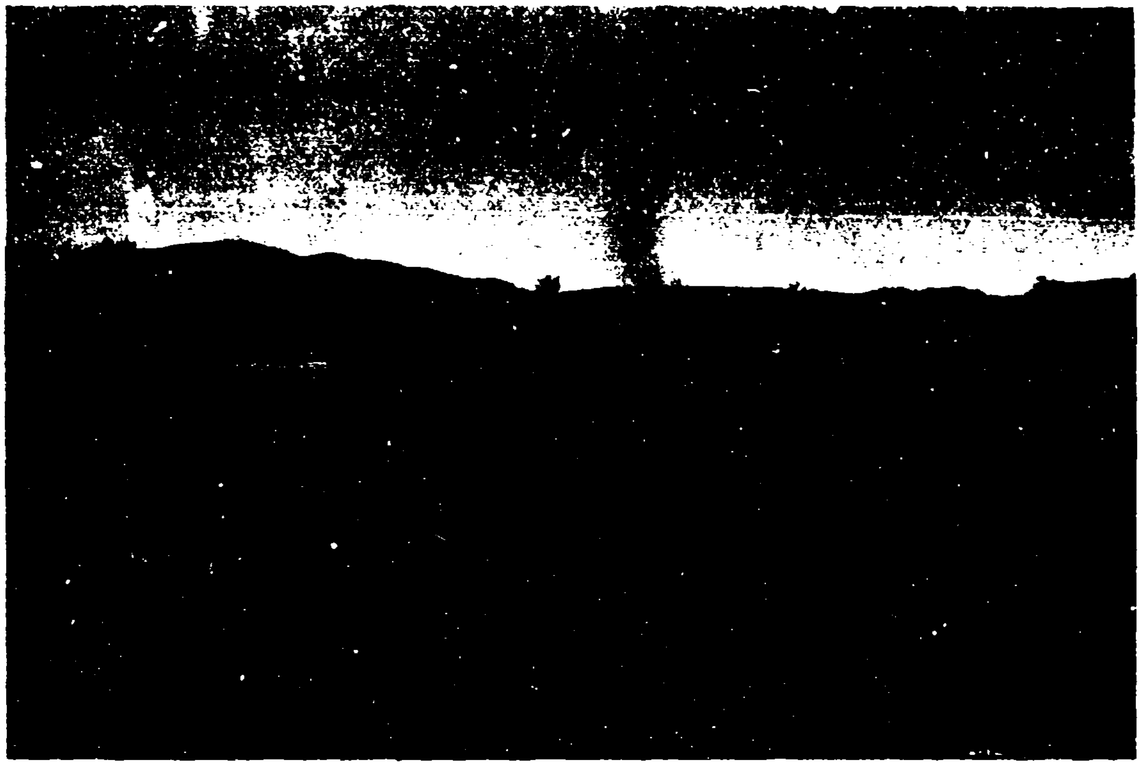

FIG. 9. Example of Dump Storage (Da Nang).

The first assumption is that the dumps will be established outside the Continental United States. This is logical because there is a complete system of NAD facilities in the Continental United States and storage at NAD is in igloo-type magazines. The second assumption is that the overseas dumps will be located near navigable bodies of water. The third assumption is that the dumps will not be near waters that freeze in the winter, making them useless until the spring thaw.

Using the above assumptions as ground rules, NWC instituted the "construction" of a worldwide series of "storage dumps". These were instrumented to reveal temperature-time histories of the ordnance skin and ordnance internal temperatures. The exposure sites includes NWC; U. S. Marine Mountain Warfare Training Center, Bridgeport, California; and U. S. Naval Magazine, Subic Bay, Republic of the Philippines. Data have been received and reduced continuously from these measurement centers for the past 1-1/2 to 3 years. It is realized that this is far short of a solar cycle; however, the results should be indicative of the overall 11-year result.

TEMPERATURE

The temperature regime of fully exposed ordnance is a much misunderstood, or misinterpretated portion of the stockpile-to-target sequence. It would be easy to assume by reading the general MIL-STD temperature cycling specifications that 160 to 200°F was common for high temperature and -65 to -80°F for low temperature. It can be safely stated that the temperature extremes for any air-launched tactical propulsion system will not approach these extremes, even on the skin, during storage. In general, it is assumed that large ordnance will stabilize at a temperature very close to the daily mean temperature. The maximum and minimum temperature will be displayed on the outside surfaces. The temperature phase shift will be a direct function of the mass and density of the unit. Normal phase shifts are on the order of 1 to 3 hours.

Maximum and Duration

The maximum temperatures will be experienced in a pure desert location. The probability of dump storage in a pure desert is remote. The next most severe situation is tropical storage. The chances of this are more realistic. However, even during the Viet Nam emergency the only dump storage of guided missiles observed by the author was at forward air facilities, i.e., Da Nang and Chu Lai.

Until NWC has accumulated enough dump storage temperature data to make it possible to place this criterion into statistical context, the maximum desert dump storage temperatures will be used. As soon as statistical information becomes available, it should be immediately integrated into design parameters. Therefore, it is projected that a motor wall temperature of 140°F for 2 hours will be experienced during a maximum year in a pure desert environment.

Minimum and Duration

The assumptions stated in the "Temperature" section, being valid, lead to a situation where the temperature environment of the ordnance

will be moderated by a large body of water. Even in Greenland, the coast temperatures do not drop far below a mean low standard air temperature of -45°F during the frozen sea condition (Ref. 21). Alaskan island cities report record cold standard air temperatures of only -26°F (Ref. 17). Since ordnance in dump storage tends to assume the mean ambient air temperature, the projection should be close to this value. Therefore, it is projected that an ordnance skin temperature of -20°F for 72 hours should be adequate.

RELATIVE HUMIDITY

The relative humidity will have the widest spectrum in the unprotected dump storage environment. It is projected at:

100% at -20°F
95% at 95°F
28% at 140°F

PRECIPITATION

Ordnance items will be dump stored throughout the coastal regions of the navigable seas. This exposure will be subject to monsoon rains and thunder showers. The conditions are such that flooding can be expected. In some cases, solid precipitation may completely cover the stored ordnance resulting in a low-temperature soak and insulation condition. The foregoing low temperature data adequately covers these situations, although it must be remembered that snow and ice are effective insulators against extreme cold conditions.

Rain

All classifications of rainfall must be considered as probabilities. Therefore, the projection indicates rainfall at 2-inches per hour direct impingement for 2 hours. Since dumps are usually located in protected valleys or on level ground, this would lead to a flooding condition.

Ice and Hail

It is projected that ice build-up of 1-inch per hour may occur. Hail may approach 1-inch per hour direct impingement for 1 hour.

Snow

The projection for snowfall must be established at the maximum probability, i.e., 10-inches per hour for 2 hours.

CORROSIVE ATMOSPHERE

Since the dump will be near salt water, corrosion of exposed surfaces can be expected. This corrosion can be extremely severe in semitropical dump sites. Salt corrosion under these conditions is a function of the distance from the surf. Corrosion rates at 80 feet from the surf are nine times greater than those of an identical specimen 620 feet from the surf at the same geographical location (Ref. 20). Biological corrosion is a function of location and latitude. Because the quantitative magnitude is unknown, only a qualitative value can be expressed. It is projected that the exposure will be severe. The values given in Part 1, Table 2 are pure conjecture, based on degradation observed in the tropics.

SAND AND DUST

Dump storage of ordnance provides the extreme exposure to blowing sand and dust that is to be experienced during the stockpile-to-target sequence. The ordnance will have no protection other than that provided by their own proximity. At the present time, the numerical values of the relationship of sand and dust particle size distribution versus wind velocity are not well enough defined to be included in this report. The magnitude of the problem is well known; for example, at NWC it has been witnessed that painted surfaces have been sandblasted clean within a 2 minute period by a high velocity sandstorm. It is therefore projected that the exposure be considered severe. The indications in Part 1, Table 2 are nothing more than educated guesses. Preliminary work at NWC indicates that any "worldwide" dirt samples will include Al_2O_3 (corundum); Fe_2O_3 (jewelers rouge), and silica.

DROP, NO DAMAGE

The ordnance will probably be mishandled more in dump storage than in any other situation. The personnel involved can range from indigenous natives and infantrymen to ordnancemen. In wartime, dump storage sites are temporary; therefore, crews cannot be expected to be fully competent or highly trained in the handling of ordnance. The shock will be confined to the unit being dropped during handling. Therefore, the projection here is established at a 2 foot drop to dirt surface during stacking. Heavier items that cannot be easily manhandled will probably experience lesser drop heights.

VIBRATION

Dump storage is a nondynamic situation and there will be no movement of the ordnance item as generally associated with vibration.

RADIO FREQUENCY (RF) RADIATION HAZARD

Dump storage areas are not generally grouped near radio or radar transmitters. Also, dump sites are usually large sprawling entities. This remoteness will weaken any radio frequency field strength. Therefore, the radio frequency radiation hazard will be negligible, or not more than 1 volt per meter.

Chapter 8

AT SEA TRANSFER

Air-launched tactical propulsion systems are transferred (Fig. 10) from an ammunition ship to the combatant ship while the combatant ship is on station in deep water. This transfer is accomplished when the combatant ship and ammunition ship rendezvous at or near the combatant ship station area (Fig. 11). Twenty-four to 48 hours in advance of this meeting, the combatant ship's commander requests a complement of ordnance. The requested ordnance is then broken out of the ammunition ship's hold and stored on the main deck for as long as 24 hours in anticipation of the transfer. The combatant ship comes alongside about 80 feet away from the ammunition ship. The hi-line is attached and made ready for transfer. The combatant ship places manila rope or cotton thrummed mats on the deck and bulkheads in the transfer terminal zone. The unpalletized ordnance unit is placed in wooden transportation boxes or in canvas "coal sacks" on the ammunition ship. The crew of the combatant ship draws the load across the transfer lines while both ships are traveling at least 8.5 knots. Sea and wind conditions can be severe during the operation. It is the responsibility of the combatant ship's commanding officer to determine whether or not the transfer can be made no matter what the sea state (Ref. 18).

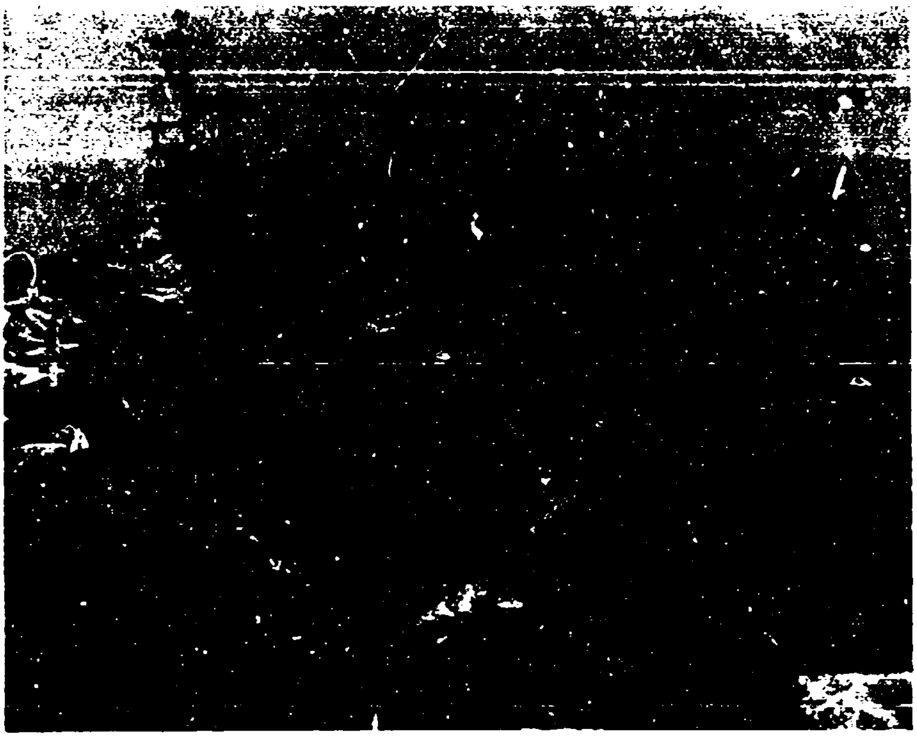

FIG. 10. Example of Ammunition Transfer at Sea by both Hi-line and Helicopter.

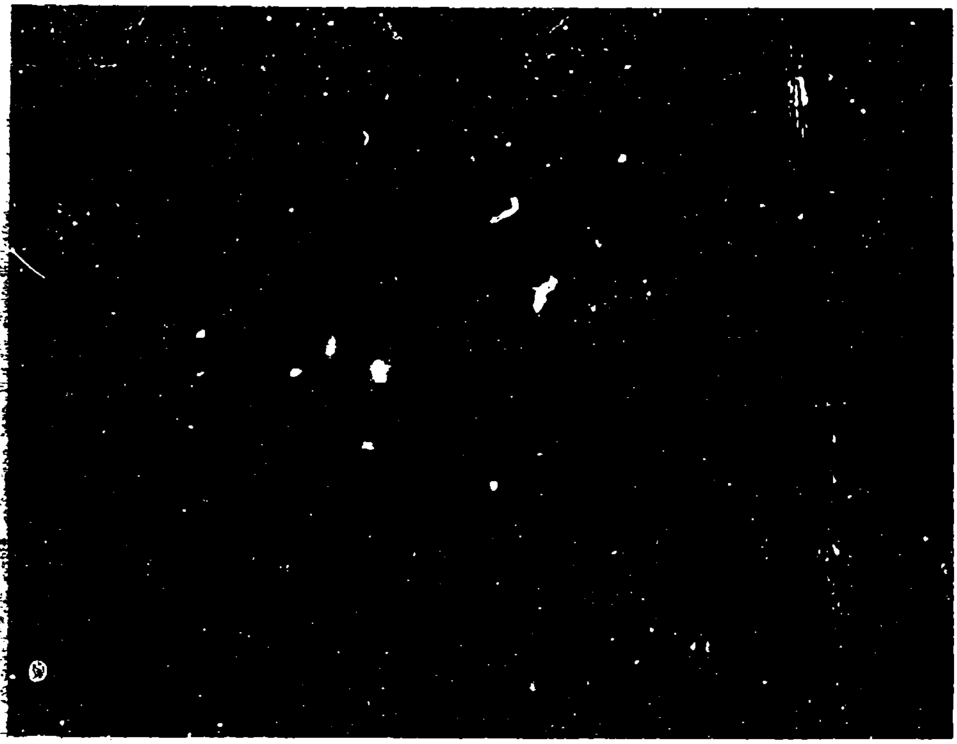

FIG. 11. Typical At-Sea-Transfer Situation.

TABLE 2. Douglas Sea Scale (Ref. 19).

Scale number	Description of the sea	Wave height
0	Calm	Less than 1 foot
1	Smooth	1 to 2 feet
2	Slight	2 to 3 feet
3	Moderate	3 to 5 feet
4	Rough	5 to 8 feet
5	Very rough	8 to 12 feet
6	High sea	12 to 20 feet
7	Very high sea	20 to 40 feet
8	Precipitous	Over 40 feet

An estimate, by ammunition ship officers interviewed, of the most severe wind and sea conditions experienced during any sea transfer of ammunition, was a state 5 sea (see Table 2). (During this transfer the ordnance loss overboard was high.) The normal sea transfer should be accomplished at a sea condition of state 2 or less. During normal conditions it is possible to drench the transferred load.

In general, the projected future for at-sea-transfer of supplies is performed during hours of darkness to avoid detection. Environmentally, this does not alter any parameter affecting the units. Consideration should be given to methods that would help personnel during a blackout sea transfer, and to protect the ordnance against possible rough handling due to darkness.

TEMPERATURE

A search of temperature extremes of island and coastal weather stations indicates a record standard air temperature of 110°F for tropical and temperate areas, and a lower limit of 0°F for arctic and temperate zones. There is a (71-year) record of 109°F for Florida, and a -26°F record temperature for St. Paul Island, Alaska. In the one case, the high temperature report is reinforced by other peak temperatures on the order of 104°F (Ref. 17).

Maximum and Duration

Based on the foregoing information, Ref. 9, and the standard air temperature versus ordnance temperature as explained in Ref. 13, the maximum temperature is projected at 100°F for 8 hours.

Minimum and Duration

The -26°F temperature was disregarded because it was obtained when St. Paul Island was locked-in by ice.

The accepted low temperature is backed up by average January subarctic sea coast temperatures of +22.9°F for a 30-year monthly average (Ref. 17). At-sea-transfer can not be carried out as described in frozen waters. Also, even if the sea is not frozen, an air temperature below +27°F will lead to ice formation on the transfer lines and the deck-stored materiel. This condition is not conducive to at-sea-transfer because of personnel safety problems. Therefore, the projection is established at 30°F for 24 hours.

RELATIVE HUMIDITY

The relative humidity at sea is usually high. The temperature-RH regime can range from 100% below 50°F to 95% at 70°F and 20% at 100°F. No values outside of this envelope are anticipated.

PRECIPITATION

Rain

Sea transfer is an activity that may be conducted during or after a rain squall; therefore, it is projected that a rainfall condition of 2-inches per hour for a period of 2 hours be expected. A maximum ambient air temperature of 80°F is anticipated during the rainfall period.

Ice, Hail, and Snow

It is not feasible to conduct sea transfer during icy conditons for reasons of personnel safety; therefore, no criteria are projected.

CORROSIVE ATMOSPHERE

Corrosion due to atmospheric exposure is negligible; however, a transfer made during a severe sea condition could result in total drenching while the ordnance is being transferred.

SHOCK

Because of the changing relative velocity across the hi-line, the load does not travel smoothly between the ships but swings like a pendulum. It is therefore possible for the transfer box or "coal sack" to slam rather violently into the transfer-terminal bulkhead on the combatant ship. In interviews with ammunition ship officers, it was estimated that the maximum impact was about 15 feet per second velocity on contact with the thrummed-pad-protected bulkhead or deck; however, there have been instances when the transfer box hit steel instead of the thrummed mat.

DROP, NO DAMAGE

The unpalletized ordnance will be much more subject to drop damage than in the other situations. The ordnance can be dropped 2 feet to steel or aluminum during transfer box unloading.

VIBRATION

Vibration experienced during at-sea-transfer is considered negligible since there is no sustained oscillatory motion. Any vibration present will be considered shock.

RADIO FREQUENCY (RF) RADIATION HAZARD

Since the ordnance is stored on the main deck for up to 24 hours before transfer to the combatant ship, it is subjected to any radio frequency energy in the area. This exposure is less than 1 volt per meter if the ammunition ship is 500 yards or more away from any aircraft carrier or guided missile cruiser type ships. During transfer to ships of these classes, all but emergency transmission will be discontinued.

The values previously stated are based on the assumption that the commanding officer of the aircraft carrier will abide by the rules set forth in Ref. 18.

Chapter 9

AIRFIELD STORAGE

The ordnance will receive its most strenuous exposure to adverse conditions in the land-based storage situation. The storage and ready service areas can range from excellent to extremely primitive (Fig. 12). In the case of any hardware that can be carried and expended from a helicopter, a propeller driven aircraft, or a light rugged jet, the storage situation can be so crude that storage in mud or dirt will be the rule rather than the exception.

FIG. 12. Arming of Aircraft by Hand, Typical of Conditions at Combat Airfield.

It cannot be overemphasized that the forward airstrip is a rugged, filthy, inhospitable circumstance to sophisticated hardware (Fig. 13). There is no comparison between this situation and the generally "antiseptic" offices and laboratories in which modern day armament is designed.

FIG. 13. Example of the Primitive Situations of the Typical Forward Airfield. (Notice ammo "dumped" beside runway.)

TEMPERATURE

Maximum and Duration

The same rules apply here that apply to the chapter on "Dump Storage". The temperature regime is identical; therefore, the projection is 140°F for 2 hours at maximum desert conditions. All other situations will lead to more moderate ordnance temperatures.

Minimum and Duration

This also is identical to the criterion as developed under the chapter on "Dump Storage" for minimum temperature. However, the forward airfield may or may not be near large bodies of water. If they are not near a

temperature moderating body of water, the lower temperature limit would depend on physiological limitations of the Marine personnel. At a primitive location, extremes in temperature would tend to halt all air operations if ready service hangars are not available. Therefore, the "dump storage" limits are used, i.e., -20°F for 72 hours.

RELATIVE HUMIDITY

The relative humidity will have the widest spectrum in the unprotected dump storage environment. It is projected to be:

100% at -20°F
95% at 95°F
28% at 140°F

PRECIPITATION

Forward airstrips can be located throughout the world. This exposure will be subject to monsoon rains and thunder showers. The conditions are such that flooding can be expected. In some cases, solid precipitation may completely cover the stored ordnance resulting in a low-temperature soak and insulation condition. The foregoing low temperature data adequately covers these situations, although it must be remembered that snow and ice are effective insulators against extreme cold conditions.

Rain

All classifications of rainfall must be considered as probabilities. Therefore, the projection indicates rainfall of 2-inches per hour direct impingement for 2 hours. Since primitive airstrips are located in protected valleys or on level ground, this would lead to a flooding condition.

Ice and Hail

It is projected that ice build-up of 1-inch per hour may occur. Hail may approach 1-inch per hour direct impingement for 1 hour.

Snow

The projection for snowfall must be established at the maximum probability, i.e., 10-inches per hour for 2 hours.

CORROSIVE ATMOSPHERE

Since the airfields will be located near salt water, corrosion of exposed ordnance surfaces can be expected. This corrosion can be extremely severe in semitropical dump sites. Salt corrosion under these conditions is a function of the distance from the surf. Biological corrosion is a function of location and latitude. It is projected that the exposure will be severe. The values given in Table 2 of Part 1 are pure conjecture, based on degradation observed in the tropics.

SAND AND DUST

Dump storage of ordnance provides the extreme exposure to blowing sand and dust that will be experienced during the stockpile-to-target sequence. The ordnance will have no protection other than that provided by their own proximity. It is, therefore, projected that the exposure be considered severe. The indications in Table 2 of Part 1 are nothing more than educated guesses. Preliminary work at NWC indicates that any "worldwide" dirt samples will include Al_2O_3 (corundum), Fe_2O_3 (jeweler's rouge), and silica.

DROP, NO DAMAGE

The ordnance will probably be mishandled at a forward airstrip more than in the storage dump. The personnel involved can range from flight crews to ordnancemen. These men are usually overworked and tired.

The shock will be confined to the unit being dropped during handling. Most of the handling, even of medium sized missiles, is by hand. Therefore, the projection is established at a 2 foot drop to a dirt surface during loading operations. Heavier items that cannot be easily manhandled will probably experience lesser drop heights.

VIBRATION

Storage is a nondynamic situation and there will be no movement of the ordnance item as generally associated with vibration.

RADIO FREQUENCY (RF) RADIATION HAZARD

At large airbases, the radar and radio field strenghts can be potentially as dangerous as those on an aircraft carrier. However, the radio frequency field strength will be dissipated by the area of the airfield

alone. At small forward airstrips less powerful electronic gear is usually used. This leads to less severe radio frequency field strengths. Therefore, the pure conjecture is herein advanced that the maximum radio frequency field strength would be no more than 100 volts per meter. This should be measured.

Chapter 10

AIRCRAFT CARRIER STORAGE

All Naval air-launched tactical propulsion systems must be capable of operation from the deck of an aircraft carrier. The carrier is unique in some environmental respects, and ordinary in others. The dynamic environment, i.e., shock and vibration, induced during catapult and arrested landing can cause problems. Since storage space is extremely limited, the "makeshift" storage may be unexpectedly rough on the unit.

There is not an abundance of sequential information on the environment aboard an aircraft carrier. Therefore, data are not sufficient at this time to authenticate many of the statements given in the following paragraphs. The possibility of "gun tub" storage, as shown in Fig. 14, may be a reality for the less sophisticated types of air-launched ordnance.

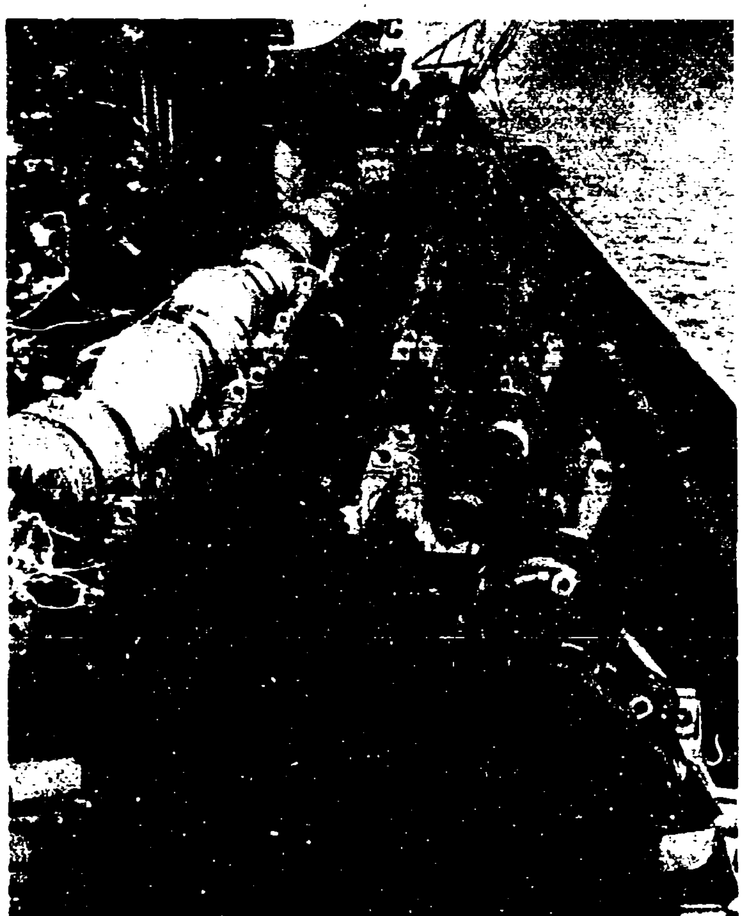

FIG. 14. Example of Space Utilization Necessary on Aircraft Carriers.

TEMPERATURE

The temperature of the storage areas on an aircraft carrier are assumed to be equivalent to those of the ammunition ship.

Maximum and Duration

The maximum worldwide seawater temperature record is 98°F, taken in the shallow water of the Persian Gulf. The tropics, however, very seldom display seawater temperatures above 85°F (Ref. 1 and 9). The magazine temperature records from ammunition ships consistently indicate that the high air temperature recorded in the ammunition ship magazine is 80°F.

Since no data have been reduced for aircraft carrier storage, the maximum temperature is projected to be 90°F for a 16 hour period.

Minimum and Duration

Since seawater is not fluid below 27°F, and aircraft carriers are deployed only in liquid state oceans, it will be assumed that this is the lower limit. In general, the recorded minimum ammunition ship magazine temperature is near 50°F. Therefore, the projected minimum temperature criterion is 40°F for 72 hours.

RELATIVE HUMIDITY

The relative humidity experienced by ordnance in storage on aircraft carriers can be generally high. It is projected that it may even be higher than on board the ammunition ship because of entrance into and exit from the magazines during the day by ship's ordnance personnel. Therefore, the projection is for 100% at 70°F to 95% at 90°F.

PRECIPITATION

Since the storage is assumed to be below decks, this category does not apply. During limited war situations the above deck gun tubs have been used for storage of inert items such as bomb fins. Air-launched tactical propulsion systems are not expected to experience this exposure.

CORROSIVE ATMOSPHERE

Location of ordnance during storage aboard aircraft carriers is planned such that there is no exposure to corrosive atmosphere other than the indigenous sea air. Since the item may be in the carrier

inventory for a considerable period of time, the projection is for a corrosion rate equal to the dissipation of 1/8-inch of hot rolled steel per year. This parameter is not well founded and extensive work must be done for verification.

SAND AND DUST

Sandstorms have been reported over coastal waters in various parts of the world; however, this is chance happening and will not be recognized as a credible circumstance. The storage is assumed to be below decks; therefore, this category does not apply.

SHOCK

The shock associated with combatant ship stowage of ordnance consists almost entirely of that derived from the movement of the ship and near misses. It is considered at this time that shock criteria established by the Bureau of Ships (BuShips) investigation and set forth in MIL-STD-910C, are acceptable. However, the shock parameters need to be made available instead of specifying a shock testing machine. Until more definitive work is undertaken to establish the shock spectrum for munitions in sea transit, the criteria as stipulated in MIL-STD-910C are acceptable.

DROP, NO DAMAGE

It has recently been established that air-launched tactical propulsion systems may not be palletized during storage in the aircraft carrier magazines. This being the case, it is assumed that it is possible to drop a single unit up to 2 feet during handling in the magazine.

VIBRATION

The vibration environment as specified in MIL-STD-167 (Ships) is adequate for low frequency. The energy levels therein are severe because MIL-STD-167 (Ships) is required for use during design of ship engines, turbines, propeller shafts, and other massive castings associated with the engine room and engineering spaces. The cargo holds will not transmit the complete high energy levels to the palletized munitions, but may excite higher frequency harmonics. Until more definitive work is undertaken to establish the vibration spectrum of munitions in the aircraft carrier magazine environment, the criteria as stipulated in MIL-STD-167 (Ships) should be used.

RADIO FREQUENCY (RF) RADIATION HAZARD

The projected value of 1 volt per meter is probably high because the ship's hull tends to act as a Faraday cage, completely shielding the ordnance from radio frequency energy. The degaussing procedures used throughout the Fleet will cause no electromagnetic hazards since all degaussing is done with direct current.

Chapter 11

AIRCRAFT CARRIER HANDLING

The handling of ordnance will occur mainly during aircraft servicing and will be done on the flight and hangar decks. Since the flight deck is included, Fig. 15, the many above-deck environments are integrated into the "storage" sequence.

FIG. 15. Arming an Aircraft with "Sidewinder" by Hand.

TEMPERATURE

Maximum and Duration

If ordnance is installed on aircraft while on the flight deck it may be exposed to solar radiation; however, the wind across the deck will moderate the temperature level. Therefore, it is projected that the temperature will be 110°F for 2 hours. This parameter is based on the author's projection only. Investigation of this criterion should be undertaken.

Minimum and Duration

During periods of exposure to temperature below 35°F, the flight deck will probably be clear of aircraft since ice formation can be expected. Any ready-strike aircraft would probably be stowed on the hangar deck in comparative warmth. If the ordnance was installed on the aircraft and the aircraft was on the flight deck, the projection would be for a temperature of 40°F for 72 hours. This parameter is based on the author's projection only. Investigation of this criterion should be undertaken.

RELATIVE HUMIDITY

The handling of an ordnance item on board an aircraft carrier will be carried out in the same indigenous RH as that found in the working spaces of the ship. Therefore, it is projected that the exposure will be from 100% RH at 70°F to 50% at 110°F.

PRECIPITATION

It will be assumed that any arming of aircraft during foul weather conditions will be accomplished on the hangar deck. However, if this is not possible, the criteria is projected to be 2-inches per hour for 2 hours.

CORROSIVE ATMOSPHERE

The corrosion rate will be negligible since the process of corrosion is a time dependent reaction. The continuation of the corrosion reaction existing during this phase will be integrated into the "ship-board storage" exposure.

SHOCK

The shock associated with handling will consist mostly of "transportation" shock sustained in transit from the magazine to the installation on the aircraft. Depending on the type of skid or dolly used, this parameter is widely variable. It is projected as a "ballpark" figure that this would approximate 15 *g* for 11 to 18 milliseconds duration. This is pure conjecture. Investigation of this situation is urgently needed and should be undertaken immediately.

DROP, NO DAMAGE

Since the conditions are as stated previously under "Shock", the major sources of drops are in the magazine, and during installation on

the aircraft. It is projected that this drop should not be more than 2 feet. A drop of any greater height would be precluded by the weight of a non-man-carried item. If the item is man-carried, the man will probably fall with the item, thus cushioning the drop. Therefore, a drop of 2 feet to steel is projected. The in-Fleet fact is that any item dropped this distance will probably be consigned to "Davy Jones' Locker" immediately.

VIBRATION

The handling will consist of a series of shocks, nonrepeating nor sustained, as previously detailed under "Shock" and "Drop, No Damage". Ignoring the background ship vibration covered in the "stowage" section, it is projected that there is no vibration.

RADIO FREQUENCY (RF) RADIATION HAZARD

Assuming clear weather conditions and rearming of aircraft on the flight deck during launch and recovery conditions, the radio frequency hazard is maximum. Since the "near field" cannot even be measured by present techniques the criterion will be stated in "far field" terms. It is projected that a 300-volt-per-meter field can exist. Criterion determination work is urgently needed to develop "near field" measurement equipment so that this parameter can be more suitably defined.

Chapter 12

ABOARD JET AIRCRAFT

The air-launched tactical propulsion system may or may not be carried aboard patrol or carrier air patrol (CAP) aircraft for extended periods of time. (Fig. 16.) In the case of many air-to-air rockets, flight times of 100 hours have been reported by the ordnance personnel. (The Sparrow is checked by Marine Air Wing 11 after each 15 flight hours.) If this experience can be related to other air-launched items, then this section has meaning. If, however, the unit is dumped before return to the carrier or Marine Corps airfield, then this section should be ignored. It is the job of the designer to assure a returnable ordnance item in the interests of pilot confidence and cost effectiveness. This portion of the unit's life will need investigation for each family of air-launched propulsion systems. It is here that the tactical useage of the unit determines its environmental uniqueness.

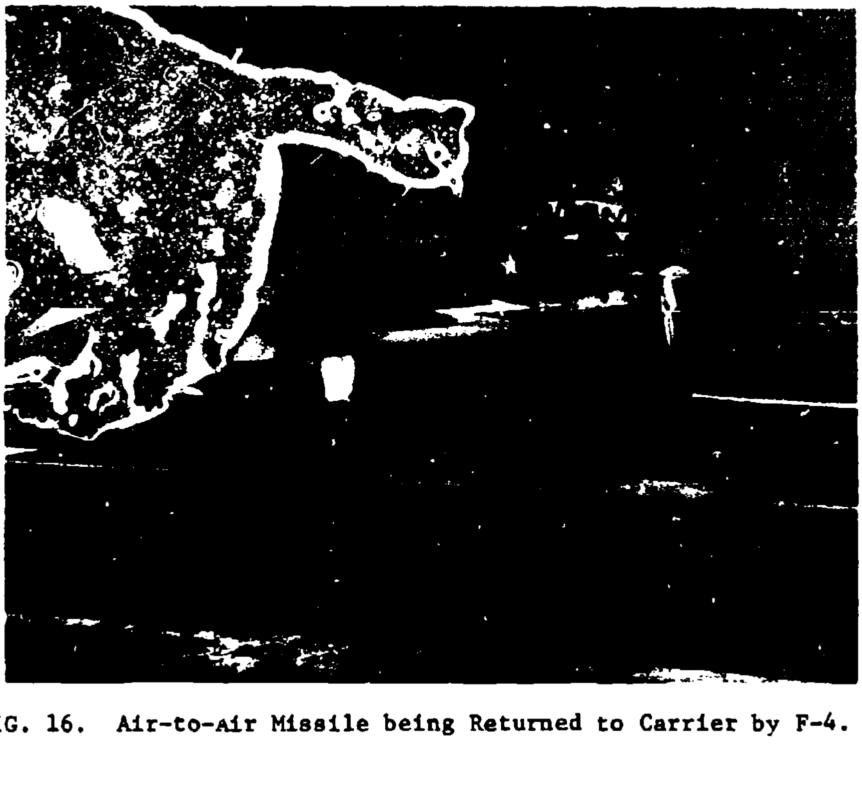

FIG. 16. Air-to-Air Missile being Returned to Carrier by F-4.

TEMPERATURE

Maximum and Duration

The maximum in-flight temperature is dependent on the mass and shape of the unit and the time of exposure to the aerodynamic thermal driving force. The projection will be based on a high-speed dash, of a duration to exhaust the fuel reserve of the high performance aircraft. Also, a more likely projection will be based on a normal external fuel condition, lower velocity maximum performance versus maximum airtime "combat" profile. The projections are based on flight measurements done on the Sparrow and liquid Bullpup missile systems at NWC in 1965-67. The projections are for 240°F skin temperature for a duration of less than 20 minutes. This envelope should be conservative enough for ordnance items 6- or 8-inches in diameter with a weight of less than 50 pounds. The second projection is 120°F for 2 hours and is the general case. Any real tactical situation must allow fuel for a return trip.

Minimum and Duration

The minimum temperature conditions will be experienced during the CAP flight at high altitude for a maximum-time-aloft mission. Based on only three measured excursions at NWC in 1966-67, the projection would be -10°F for 2 hours. The lower temperature asymptote has been tentatively established at -10°F. Unconfirmed reports have stated that other temperatures have been experienced. Although verification of these reports has not been established, they are herein recognized for lack of better data. The projection is -25°F for 2 hours. This value is in doubt and should be investigated.

RELATIVE HUMIDITY

During the "aircraft carried" time of the ordnance life, the only time that the air temperature is generally above 32°F is when the aircraft is taking off, landing, or below 20,000 feet. The excursion into air 32°F or lower negates the concept of RH since the water vapor is now in the form of ice crystals, and the ratio of water to dry air is less than 0.004. The projection will be based on the same three conditions predicted for the aircraft carrier or land station. The projection is for 100% RH at 70°F to 45% at 90°F.

PRECIPITATION

The precipitation values are limited by the ability of the aircraft to fly through a given storm. The following projections are very arbitrary. The basis is generally the water content of ingestion or icing

to be expected if the mission proceeded. The projection is for 0.5-inch per hour of rain, ice, or hail, and 3-inches per hour of snow. These precipitation rates are extremely high for mission completion.

CORROSIVE ATMOSPHERE

This parameter need only be considered if the item is returnable. If so, the corrosion rate will be equal to the most extreme seen aboard an aircraft carrier or on a tropical island. This rate is equal to the dissipation of 1/8-inch of hot rolled steel per year.

SAND AND DUST

This parameter relates to the take-off and landing situation on land only. The severity of the parameter must be tempered since too much ingestion of sand and gravel will destroy the jet engine of the carrying aircraft. The projection is for a 100 knot relative velocity to the ogive of the unit with particle sizes of 0.001- to 0.125-inches diameter. The composition of the sand or dirt also contains Fe_2O_3, Al_2O_3, and silica.

SHOCK

The maximum shock expected will be experienced during arrested aircraft carrier landings at sea or Morris gear landings on land. The following is based on very old, unverified measurements obtained on World War II aircraft, not armament. The projection is for 35 $\underline{g}$, 5 to 15 millisecond duration. This parameter needs thorough investigation.

VIBRATION

The in-flight vibration of any air-launched tactical propulsion system will in general be more random than sine. The following is pure conjecture since a credible measurement of the parameter on ordnance items has not yet been determined. It is projected that a power spectral density of $0.0125\underline{g}^2$/cps over the frequency band of 2 to 2000 cps will be close to reality.

RADIO FREQUENCY (RF) RADIATION HAZARD

The radio frequency hazard will be potentially the greatest during this phase of the item's life. The armed aircraft will be subjected to the aircraft carrier flight deck "near" and "far field" radiation. Therefore, the maximum value of 300 volts per meter is projected. Since "near field" cannot, at present, be measured it is mandatory to develop equipment for the measurement of the total parameter.

Chapter 13

ABOARD PROPELLER DRIVEN AIRCRAFT

The propeller driven aircraft (Fig. 17) has staged a come back in the limited warfare situation. The old World War II types still in existence have been used extensively in Viet Nam and Korea. New contracts have been negotiated for the development of counter-insurgency (COIN) aircraft. Therefore, air-launched ordnance may be carried on this type of aircraft for some time.

FIG. 17. Propeller Driven Aircraft, Ready for a Mission.

The propeller driven aircraft is typified, when compared with jet propelled aircraft, by less than Mach 1 velocity. The speeds are much closer to 450 miles per hour and under.

Their maintenance needs are quite primitive and take-off distances are much shorter. The propeller plane can operate out of extremely crude advanced airstrips. Therefore, the ordnance delivered from these planes must be more rugged to keep pace with the method of delivery.

TEMPERATURE

The temperature regime associated with propeller-aircraft-launched ordnance will be less extreme than those associated with jet aircraft.

Maximum and Duration

The maximum aerodynamic heating temperature to be encountered on air-launched ordnance will be less than 110°F. The maximum speed of a propeller driven aircraft is not great enough to do much more than maintain the ordnance at ambient ground temperature with aerodynamic heating. Therefore, the projection is a maximum temperature of 110°F for 2 hours.

Minimum and Duration

The minimum temperature that ordnance would experience is close to the ambient air temperature. Propeller driven aircraft are not used for high altitude missions; therefore, they will not be flying at altitudes much in excess of 20,000 feet. Normally, when on a strike, the altitude will be much lower. At 2,000 feet above the ground, terrain can start to blend into a meaningless patchwork. Therefore, for maximum target spotting ability, the mission will be low level. The air temperature in arctic regions can hover between -20 and -40°F for days on end and the propeller driven aircraft can be used to support troops at these temperatures. Aerodynamic heating at 250 knots would have negligible effect on the ordnance. Therefore, there will be little moderation of the soak temperature of ordnance from the free air value. A criterion of -30°F for 2 hours is projected. This is extremely arbitrary and work needs to be done to define the above assumptions.

RELATIVE HUMIDITY

The relative humidity experienced by ordnance while carried on slow, low flying aircraft will be identical to the most extreme encountered on land. Therefore, the projection is for 100% RH at 70°F and below, 95% at 95°F, and any combination of temperatures and humidities that is consistent with 0.035 pounds of moisture per pound of dry air.

PRECIPITATION

The precipitation values are limited by the ability of the aircraft to fly through a given storm. The following criteria are very arbitrary. The basis is generally the water content of engine ingestion or icing to be expected if the mission proceeded. The projection is for 0.5-inch per hour of rain, ice, or hail, and 3-inches per hour of snow. These precipitation rates are extremely high for mission completion.

CORROSIVE ATMOSPHERE

If the item is returned and recarried, the corrosion rate can be equal to the most extreme experienced aboard an aircraft carrier or in a storage dump. This is equal to the dissipation of 1/8-inch of hot rolled steel per year. This prediction is extremely arbitrary and in vital need of investigation.

SAND AND DUST

This parameter relates to land based aircraft only. The severity of the parameter must be tempered since ingestion of dirt will destroy aircraft engines. (B-24 bombers of the U. S. Army Air Force in World War II had severely abbreviated engine life when based in Libya.) The projection is for a 100 knot relative velocity to the ogive of the ordnance, with particle diameters of 0.001- to 0.125 inch. The makeup of the sand and dust will include SiO_2, Al_2O_3, and Fe_2O_3.

SHOCK

The maximum shock expected will be experienced during arrested landings, i.e., aircraft carrier or land-based Morris gear. The criterion is based on World War II aircraft data. The projection is 35 g, 5 to 15 millisecond duration.

VIBRATION

In general, the vibration of propeller-aircraft-carried ordnance will consist predominantly of sine wave vibration. The general band of exposure will be ±5 g from 2 to 500 cps. This value is dependent on size of the item and placement on a particular aircraft. For a given system, it is strongly advised that a measurement sequence be established.

RADIO FREQUENCY (RF) RADIATION HAZARD

The radio frequency radiation hazard will be potentially the greatest during this phase of the item's life. The armed aircraft will be subjected to the aircraft carrier flight deck "near" and "far" field radiation. Therefore, the maximum value of 300 volts per meter is projected. Since measurement of "near" field is not at present possible, the value is presented in "far" field terms. Effort needs to be expended to more fully investigate and totally define this criterion.

Chapter 14

LAUNCH FROM AIRCRAFT TO TARGET

This section is concerned with the portion of the rocket's life in which it must function as designed. In all the preceeding sections the item must survive in a good enough condition to function when required.

There have been very few actual measurements obtained during this portion of the unit's life; therefore, most of the following borders on pure guess. The need is great for measurements in this "moment-of-truth" area. Each system, or family of systems, will exhibit unique characteristics during this portion of the total life. The launch-to-target phase (Fig. 18) of each must be studied so that insight can be gained into anomalies that may work in the designer's favor. Conversely, there may be unique factors detrimental to successful function that are not readily apparent.

FIG. 18. Launch of an Air-to-Ground "Shrike".

TEMPERATURE

Maximum and Duration

The projection is based on a Mach 2 aircraft velocity at launch. The time of flight is approximate. The aerodynamic heating temperature depends on shape, size, and point of measurement. As an overall guess it is projected that the round will be subjected to 400°F skin temperature for 30 seconds, or duration of rocket flight.

Minimum and Duration

If the unit is expended during the latter portion of a CAP flight, it will have been cold soaked. The time of flight of the propulsion system will not add much heat to the round. Therefore, a temperature of -25°F for 30 seconds is projected. This is arbitrary, though based on Sparrow and Bullpup captive flight data obtained at NWC.

RELATIVE HUMIDITY

The relative humidity at launch above 20,000 feet is meaningless because of the air temperature. If an item is released below 10,000 feet then the projection is identical to the aircraft carrier or tropic island value of 100% RH at 70°F to 45% at 90°F. It would be a rare day that exhibited even 70°F at 10,000 feet altitude.

PRECIPITATION

This parameter is difficult to assess. The navigation of an aircraft will limit any mission. Even assuming that something other than the launching aircraft is providing electronic navigation signals, it may be possible to operate only in moderate conditions. The guess would be about 0.5-inch of rain per hour, 0.5-inch of ice or hail per hour, or a 3-inch per hour snowfall. This parameter needs investigation before even an educated guess can be properly made.

CORROSIVE ATMOSPHERE

Since corrosion is a time dependent action and this sequence is completed in about 30 seconds, corrosion is considered negligible.

SAND AND DUST

Since sandstorms are a phenomenon associated with altitude 2,000 feet above the earth's surface or lower, this parameter does not apply.

SHOCK

The overall shock associated with launch consists of an aggregate of ignition shock, ejection shock, and detent release shock. For an item that weighs 120 to 200 pounds, the projection will be for detent shock of 20 *g* for 30 milliseconds or an ejection shock of 30 *g* for 5 milliseconds. For an item 200 pounds or greater, the shock would be 13 *g* for the same launcher. The ignition shock must be measured for each family. The above projection is an educated guess based on some NWC weapons. This parameter is not fixed and measurements need to be taken.

VIBRATION

The vibration excursion for any in-flight system is as unique as a signature. The locus of values is not even known. Therefore, no generalized projection that would have any meaning can be made. This parameter is in paramount need of measurement. The measurement must be done for each weapon or family of weapon systems.

RADIO FREQUENCY (RF) RADIATION HAZARD

The radio frequency radiation hazard may or may not apply at this stage of the unit's life. The initiator has been expended and any propulsion is in operation. The only radio frequency existing would possibly be guidance energy. If the judgement is made that the parameter does apply, then 10 volts per meter for 30 seconds is projected.

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

This report (Part 2) provides the technical support for the stockpile-to-target sequence (Part 1). Table 2 of Part 1 (the stockpile-to-target sequence) is included for convenience of the reader as a cross-reference to the chapters of this report. Each criterion presented in Part 1 is explained in an appropriate chapter. When the criterion is based on conjecture or pure guess, or where work is needed to define the environment, this is noted.( )

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Environment						
Environmental criteria						
Temperature						
Relative humidity						
Precipitation						
Corrosive Atmosphere						
Sand and dust						
Shock						
Drop, no damage						
Vibration						
Radio frequency (RF) radiation hazard						
Environmental philosophy						
Stockpile-to-target sequence						

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